THURSDAY, OCTOBER 2, 1879

THE GREENWICH METEOROLOGICAL OBSERVATIONS

Reduction of Greenwich Meteorological Observations. Barometer, 1854–1873; *Air and Moisture Thermometers*, 1849–1868; *and Earth Thermometers*, 1847–1873. Made at the Royal Observatory, under the Direction of Sir George Biddell Airy, K.C.B., Astronomer-Royal. (London, 1878.)

AN important contribution has recently been made to the meteorology of England by the Astronomer-Royal in the issue of this volume, which contains elaborate discussions of the photographic records of the barometer from 1854 to 1873, of the photographic records of the dry-bulb and wet-bulb thermometers from 1849 to 1868, and of the eye-observations of the thermometers whose bulbs are sunk to different depths in the ground from 1847 to 1873. The photographic apparatus and the details of the instruments and their mounting are fully described, and the methods for the reduction of the photographs to numbers, and the discussion of the results, are explained at length.

There can be no doubt that in these twenty years' averages we have the closest approximation to the mean monthly diurnal inequality of the barometer, in other words, to one of the prime factors of the meteorology of Greenwich. Of special interest are the results for the warmer months of the year, which class Greenwich among the places in middle and higher latitudes, whose climates are more or less continental in their character—these more special features being the occurrence of the forenoon maximum as early as 9 A.M., and a marked diminution in the amount and amplitude of the morning minimum. The almost strictly local character of the diurnal phases of atmospheric pressure, as disclosed by the observations at Greenwich, is seen from the occurrence of the A.M. maximum an hour earlier at Kew, where also the A.M. minimum becomes still less pronounced than that of Greenwich. On the other hand, at Falmouth, the A.M. minimum is much the greater of the two daily minima, and the A.M. maximum is delayed from two to three hours later than at Greenwich. Hence the true value of the Greenwich results can only be appreciated after a comparison has been made between them and the results obtained from other meteorological observatories.

An extremely interesting discussion has been carried out, showing the relations between the diurnal inequality of pressure and the different directions of the wind for the months. The results, while showing the double maxima and minima, show also in every case that the diurnal curve is thrown up or down, sometimes very considerably so. The reason for this uptilting of the curves or the reverse, is readily seen if we refer the phenomena to the European storms which affect the winds and pressure at Greenwich in their eastward course. Thus E., S.E., S., and S.W. winds, being in the front segment of storms, are accompanied with a falling barometer, and consequently the curves of diurnal inequality of pressure for each of these winds appear thrown down, most so in case of S.E. winds; whereas W., N.W., and N. winds which prevail in the rear of storms and are attended with a rising barometer, present curves which are thrown up, the uptilting with N.W. winds being remarkably great. These effects are most decided during the stormiest half of the year.

The observations of temperature are discussed with particular fulness, and the length of time is sufficient to give curves showing a diurnal inequality of temperature such as will substantially represent the curves for large portions of the south of England, not bordering the sea, where the thermometers are similarly placed to those at Greenwich.

The curves of temperature for the different winds have also been worked out with much elaboration, and give most interesting results. We would refer specially to the diagram on page 18, showing the air-temperature curve for December, with the diurnal curve for the same month, when the N.W. wind blew, from which it is seen that while the curve for N.W. winds has substantially the same form as the general curve for the month, it superadds a gradual fall of about 4°·0 during the twenty-four hours. On comparing the temperature of the air at midnight with that at the following midnight, it is shown that a clear sky lowers the temperature considerably in November, December, and January, but raises it in other months, particularly in May, June, and July; whereas an overcast sky scarcely disturbs the temperature, so that on an average it stands at the same point at the end as at the beginning of the twenty-four hours. On the average of all months the N. wind is the coldest, the S.W. the warmest; the order as regards temperature, beginning with the coldest, is N., N.E., N.W., E., S.E., W., S., S.W.—an order, however, which differs in different months. The results of changes of wind differ greatly with season; thus a change of wind from N.E. to S.W. raises the temperature 11°·0 in January, but only 0°·3 in June.

The earth thermometers were made under the superintendence of the late Prof. J. D. Forbes, and placed in position in 1846, the graduation of these thermometers having been made by Prof. Forbes himself. The hour of observation has been noon, but during 1846-47 observations were made every two hours, from the results of which "corrections" have been obtained for the reduction to approximate mean temperatures. The following are among the more important results:—

	Earth thermometers at depth of				
	1 inch.	3·2 feet.	6·4 feet.	12·8 feet.	25·6 feet.
Mean coldest month . . .	Jan. 40°·38	Mar. 42°·48	Mar. 44°·79	Apr. 46°·42	June 48°·94
Mean warmest month . . .	July 64°·34	Aug. 61°·38	Aug. 59°·60	Sept. 55°·74	Nov. 52°·21
Difference . .	23·96	18·90	14·81	9·32	3·27
Mean annual temperature	51·24	51·13	51·53	50·87	50·55

The mean temperature of the air from observations made with a thermometer in the perforated wooden box protecting the projecting scales of the thermometers is 51°·59. But with the view of giving a more exact comparison between the temperature of the air and that of

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the earth, a table (p. 100) of the mean monthly temperatures of Greenwich from October, 1846, to December, 1873, is given. The method by which this table was constructed is thus described :—

"The values for 1847 are the simple means of two-hourly observations; those for 1848 are the means of usually six observations daily, corrected for diurnal inequality by application of corrections derived from Mr. Glaisher's paper 'On the Corrections to be Applied to Meteorological Observations,' in the *Philosophical Transactions* for 1848, Part 1. The means for 1849 and all succeeding years are found by combining eye-observations, taken usually four times on each day, and corrected for diurnal inequality, with observations of the maximum and minimum corrected by a quantity (taken from Mr. Glaisher's paper) peculiar to the period of the year. These temperatures may be regarded as accurate mean temperatures."

From this table the annual mean temperature of Greenwich comes out as 49°·43, being 1°·9, 1°·7, 2°·1, 1°·4, and 1°·1 in excess of the earth thermometers from the surface downwards. This large excess raises a doubt as to the correctness of the method adopted in calculating the mean temperature at Greenwich. Looking at Table 43 we find the mean temperature at every hour of the day for the month of June, with the number of days each, of the years for which observations were available for striking the means. On eight of the years the record was complete, and on these years, therefore, the mean temperatures deduced by the two methods should agree closely, if the method of calculating the means quoted above be a correct one. A comparison shows that in none of the months is there any agreement, the extreme differences being 1°·5 for June, 1865, and 0°·7 in June, 1863, and the mean difference for the whole eight years, 1°·0. The true mean—that of the twenty-four observations each day—is in all these cases in excess of the other mean. Similarly May, October, and January were examined, with resulting mean differences of 0°·5, 0°·3, and 0°·2 respectively. It follows that the mean temperatures, which are the most important element in the climate of Greenwich, remain still to be calculated.

When this has been done it will probably be found that the mean annual temperature of Greenwich has been understated by half a degree, and that consequently the mean for the twenty-eight years ending with 1873 was 50°·0. This supposition is rendered the more probable by applying the noon correction from Greenwich daily inequality tables to the mean of the temperature inside the perforated box protecting the earth thermometer. The mean annual temperature then becomes 50°·1.

In a large number of the years the third barometric maximum, first noticed by Rikatscheff as occurring in certain regions of the globe a little after midnight, appears in the Greenwich diurnal curves for December, January, and February, less frequently in March, and seldom or not at all in the other months. The somewhat rough method which has been adopted in reducing the barometric observations to 32° unfortunately renders the evidence furnished by the Greenwich results regarding the more refined inquiries of meteorology, such as this, and the mean diurnal inequality of the barometer in the lunar months, not so satisfactory and conclusive as might have been wished.

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CHEMICAL DENUDATION AND GEOLOGICAL TIME

Chemical Denudation in Relation to Geological Time. By T. Mellard Reade, C.E., F.G.S., Past President of the Liverpool Geological Society. (London: David Bogue, 1879; pp. 61).

THIS little book is made up of three papers: one on "Geological Time;" a second on "The Geological Significance of the *Challenger* Discoveries;" and the third on "Limestone as an Index of Geological Time." The last paper was read before the Royal Society in January, 1879, and the others have been read before the Liverpool Society, of which the author is a distinguished member. Although, therefore, not new, these papers are well worth reading, for a vast amount of good solid fact is environed by curious calculations, and by hypotheses of a highly exciting nature. That is to say, exciting to the prosy realistic disposition of modern geology. This meritorious work, however, is slightly depreciated by the introduction of matter which is not strictly consistent with the results of modern research. Nevertheless, on the whole, the work may be considered very satisfactory by those who believe that doubt is the mother of progress; for all the hypotheses and conclusions in it are the product of a geological imagination of the highest and most vigorous order, and are of course open to objection. In the introduction it is stated that the author, during an attempt to estimate the amount of "solid matter conveyed annually in solution" in river-water to the sea from the surface of England and Wales, had a "new modulus" come into his mind, which might enable him to gauge the vista of the immensity of past time, or rather to arrive at "a minimum limit to the age of the earth." The result is thus stated: "If we imagine the area of England and Wales consisting of 58,300 square miles, to form one river-basin, the delivery of water by such river would be 68,450,936,960 tons, or 18·3 inches per annum, containing a total of 8,370,630 tons of solids in solution, representing a general lowering of the surface from that cause alone of ·0077 of a foot per century, or one foot in 12,978 years." Taking the "soluble denudation" of other parts of the world into consideration, Mr. Reade considers "that about 100 tons of rocky matter is dissolved by rain per English square mile per annum." This he states contains 50 tons of carbonate of lime, and twenty of sulphate of lime, &c., and proceeds: "If, as is generally supposed, the sea contains only what is washed into it from the land, and we can estimate its numeral contents in tons, we at once get a minimum measure of the age of the earth." As Herschel states that the ocean contains 2,494,500 billions of tons of water, and the mean of Dr. Frankland's analysis gives 48·9 tons of carbonate of lime and magnesia, and 1,017 tons of sulphate of lime and magnesia in 100,000 tons, it follows, according to the author, that it would take 25,000,000 of years to accumulate the quantity of sulphate of lime and magnesia contained in sea water, but only 480,000 years to renew the carbonate of lime and magnesia, and the discrepancy is caused by the appropriation of the calcic carbonate by mollusca for their tests. The amount of visible sediment brought down mechanically by rivers, as calculated for the whole world upon the results of Humphreys and Abbot for the Mississippi, and the